(12) UK Patent Application (19) GB (11) 2 065 896 A

(21) Application No 8040320
(22) Date of filing 17 Dec 1980
(30) Priority data
(31) 2951139
(32) 19 Dec 1979
(33) Fed. Rep. of Germany (DE)
(43) Application published
1 Jul 1981
(51) INT CL³
B60C 23/04 G01D 5/243
(52) Domestic classification
G1N 1A2C 1D3 1D5 3S11
4F2 7C AHC
G4N 1C1 1P 4C 5A3 6V
DG
(56) Documents cited
GB 1383360
GB 1382877
GB 1311585
GB 1153900
(58) Field of search
G1N
G4N

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(54) Apparatus for Continuously Monitoring the Air Pressure in Vehicle Tyres

(57) An apparatus for monitoring the air pressure in the tyre of a vehicle wheel comprises a magnetic field producing device 6 which is fixed to the vehicle wheel and rotates with it. An induction loop 7 is positioned at a fixed location on the vehicle adjacent to the wheel and is subjected periodically to the magnetic field of the magnetic field producing device as the latter moves past it. The magnetic field is produced by passing an oscillating signal through a coil 5, this signal being generated in a resonant LC circuit whose oscillating frequency is determined by an impedance, such as an aneroid capacitor capsule 3, which varies in dependence upon the air pressure in the tyre. The coil 5 can be part of the resonant circuit 6 or can be fed by a separate oscillator, such as a multivibrator. Energy for energizing the device can be supplied electromagnetically from a fixed transmitter to an energy pick-up on the wheel.

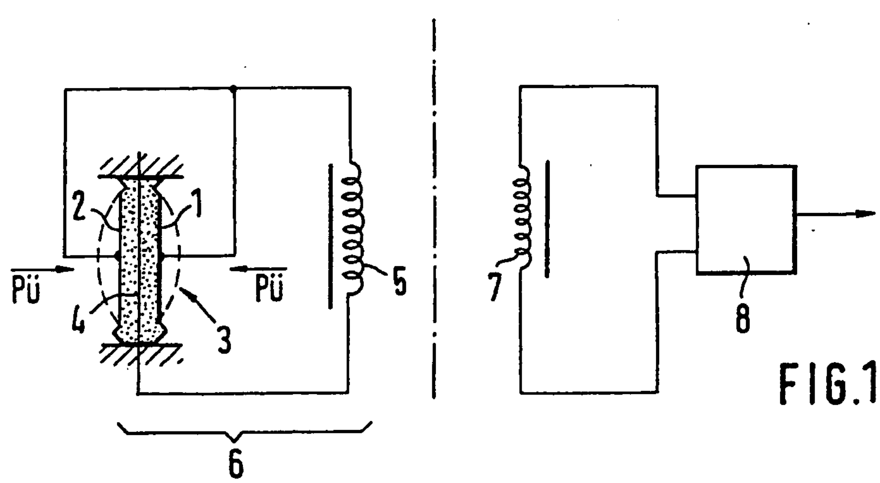

FIG.1

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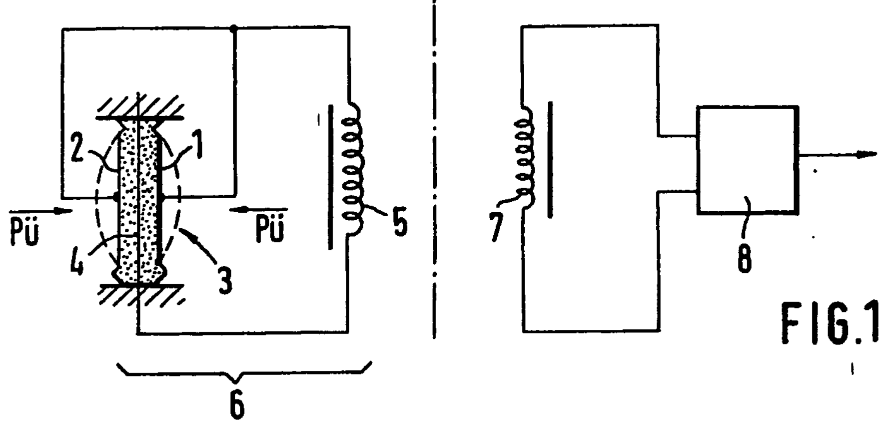

FIG.1

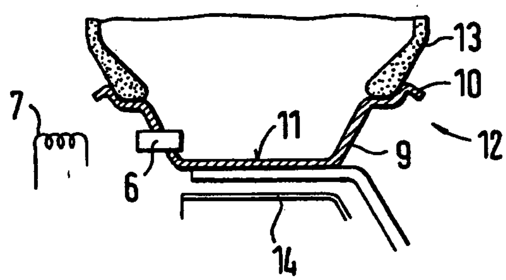

FIG.2

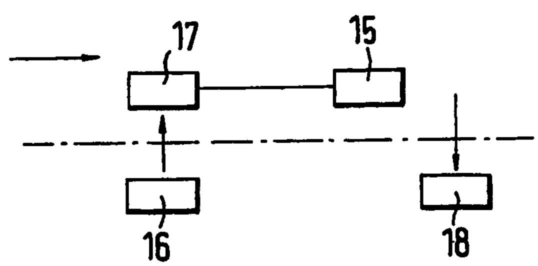

FIG.3

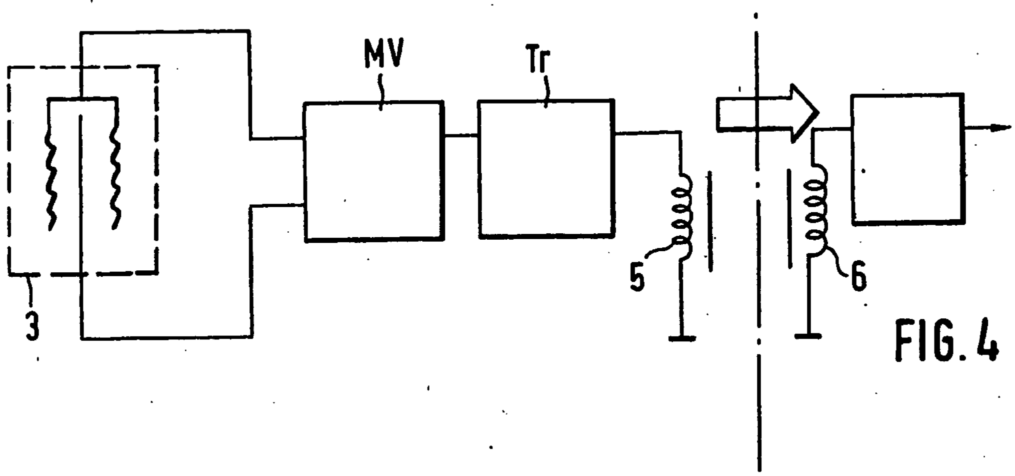

FIG. 4

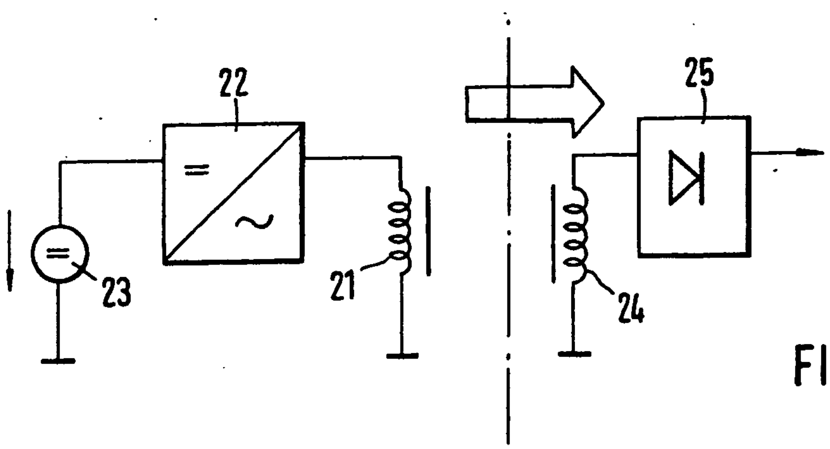

FIG. 5

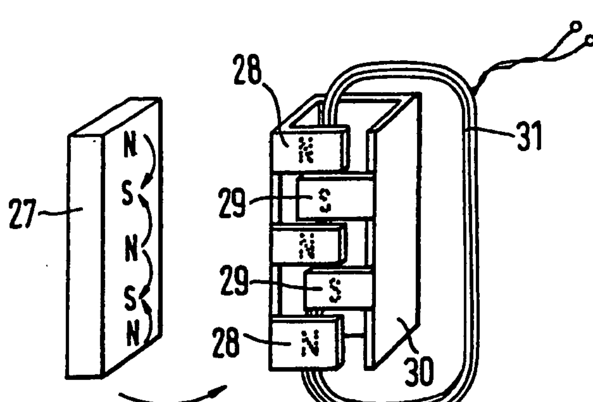

FIG. 6

SPECIFICATION

Apparatus for Continuously Monitoring the Air Pressure in Vehicle Tyres

The invention relates to an apparatus for continuously monitoring the air pressure in the tyre of a vehicle wheel.

An apparatus for this purpose is known which comprises a device which is arranged on the vehicle wheel for producing a magnetic field rotating with the vehicle wheel, and an induction loop which is secured to the vehicle and which is subjected to the magnetic field of the vehicle wheel moving past it.

An apparatus of the latter kind is known from British Patent Specification No. 1,382,877, in which a mechanical switch, subjected to the air pressure in the tyre, short-circuits a part of a magnet coil rotating with the vehicle wheel when the air pressure in the tyre drops below a critical value. In this apparatus, the induction loop secured to the vehicle is connected to a self-oscillating oscillator which is detuned by the variable inductance of the rotating magnetic coil. Monitoring the limiting value of the tyre pressure by means of a pressure switch in this manner does not take into account that fact that, during operation of a motor vehicle, the tyre pressure generally does not drop abruptly below the critical limiting value.

An object of the present invention is to give the driver of the vehicle a warning signal in good time during a gradual drop in the tyre pressure, so that the driver can stop the vehicle when a puncture is signalled.

In accordance with the present invention, an apparatus for monitoring the air pressure in the tyre of a vehicle wheel comprises a device which is arranged on the vehicle wheel for producing a magnetic field rotating with the vehicle wheel, and an induction loop which is secured to the vehicle and which is subjected to the magnetic field of said device on the vehicle wheel when said device moves past it, said device including an electro-magnetic coil for producing said magnetic field rotating with the vehicle wheel and which carries an oscillatory signal of an electrical resonant circuit whose oscillating frequency is determined by an impedance which varies in dependence upon the air pressure prevailing in the tyre.

The invention is described further hereinafter, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a diagrammatic illustration of a pressure sensor in accordance with the present invention having electromagnetic coupling;

Figure 2 is a fragmentary transverse cross section through a vehicle wheel and tyre;

Figure 3 is a block circuit diaphragm for the energy supply of the sensor of Figure 1 and for evaluating the measured values supplied thereby; and

Figures 4 to 6 show further embodiments of devices in accordance with the invention.

The pressure sensor illustrated in Figure 1 enables the tyre pressure to be measured by way of the resonant frequency of a resonant circuit. The resonant circuit includes a capacitive pressure-sensitive device which is filled with a dry reference gas or which is evacuated and which includes two outer diaphragms 1 and 2 of a diaphragm box 3 which are subjected to the air pressure in the tyre. The diaphragms are insulated from one another at their edges, although they are interconnected in a pressure-tight manner. A rigid plate 4 is clamped between the two diaphragms in an insulated manner and serves as a counter-electrode for the two outer electrically interconnected diaphragms and, together with said diaphragms, forms an electrical capacitor. When the tyre pressure, indicated by arrows, increases, the outer diaphragms move towards the plate 4 from their curved configuration (indicated by broken lines) which they assume at a very low tyre pressure, whereby the capacitance between the diaphragms 1, 2 and the plate increases. The capacitor constituted by the diaphragms and the plate is part of an oscillatory circuit incorporating a coil 5 which, together with the pressure box, forms the pressure sensor indicated at 6 in Figure 2 and, during each rotation, faces a coil 7 which is secured to the vehicle and which is in the form of, for example, an induction loop in which the coil 7 induces electrical oscillations which are measured by an oscillator circuit 8. The tyre pressure can then be continuously deduced from the natural frequency of the oscillating circuit 8.

It is possible to influence the characteristic curve by the configuration of the diaphragms 1 and 2. Alternatively, the present principle of measuring the air pressure by using the natural frequency of the capacitor formed by the coil 8 and the capacitance of the diaphragm box 3, can be realised with inductive diaphragm position sensors, such as a short-circuit ring sensor.

Since one measurement per revolution of the wheel is possible, an advantageous frequency-analog evaluation ensues at low expense.

Figure 2 shows the spatial arrangement of the pressure sensor 6 in the bridge portion 9 between the flange 10 and the well-base 11 of the rim 12 of a vehicle wheel whose tyre is indicated at 13 and whose brake drum is indicated at 14. The second coil, indicated at 7 in Figure 1 and acting as an induction loop, can be secured at the same radial distance as the sensor 6 to a stationary part of the vehicle, such as the support disc (not illustrated) for the brake shoes and the wheel brake cylinder.

In contrast to the arrangement of Figure 1 in which the pressure sensor 6 is part of a passive resonant circuit, the tyre pressure can be measured by way of the resonant frequency of an active resonant circuit which is used in a measuring transmitter 15 rotating with the wheel. Referring to Figure 3, the measuring transmitter 15 can receive its energy from a stationary energy transmitter 16 which, by way of a magnetic field,

couples energy with a frequency of approximately 20 kHz into an energy receiver 17 rotating with the wheel. The electrical energy received in the energy receiver 17 can be used to operate the measuring transmitter 15 whose natural frequency is varied in dependence upon pressure in the same manner as in the embodiment of Figure 1 and is monitored by means of a stationary measuring receiver 18. Shortly before the measuring transmitter 15 rotates past the measuring receiver 18, the two coupling units comprising the energy transmitter 16 and the energy receiver 17 are located congruently opposite one another and enable transmission to the rotating wheel of the energy required for a short period of oscillation of the measuring transmitter 15. Direct cross talk from the energy transmitter 16 to the measuring receiver 18 can be avoided by using different frequencies for the supply signal and the measuring signal. The rotating coupling point 17 as well as the energy transmitter 16 and the measuring receiver 18 can be in the form of compact units.

Although the arrangement of Figure 3 is somewhat more expensive, it offers a greater margin of safety against falsification of the measured values by fluctuations of distance between the transmitter and receiver parts.

The time available for energy supply at maximum speed is approximately 2 ms, which requires a transmission frequency of approximately 10 to 20 kHz for the energy transmitted from the energy transmitter 16 to the energy receiver 17, while the measuring frequencies of the measuring transmitter 15 vary advantageously between 50 and 100 kHz in dependence upon pressure.

The embodiment of Figure 4 is provided with the same capacitive pressure-sensitive device 3 as that which is shown in Figure 1 and which is further described above. In contrast to the embodiment of Figure 1, the capacitive pressure-sensitive device 3 of the embodiment of Figure 4 constitutes the frequency-determining member of an astable multivibrator MV which, by way of a driver stage Tr, controls the pressure-dependent oscillator frequency of the current flowing through the coil 5. As soon as the coil 5 moves past the induction winding 6 connected to the chassis of the motor vehicle (otherwise not illustrated), it induces in this winding an alternating voltage whose frequency varies together with the pressure in the tyre of the vehicle wheel.

The relaxation oscillator MV oscillates at a frequency which is proportional to 1/CR, C being the capacitance varied in dependence upon pressure, and R being the effective resistance of the frequency-determining relaxation circuit when in its actuated state. The frequency swing of an oscillator of this kind is substantially greater (approximately twice as great) as that of a harmonically oscillating LC resonant circuit of the kind provided in the embodiment of Figure 1 and whose natural frequency corresponds to the known Thomson formula

$$f = \frac{1}{LC}.$$

In order to supply current to the multivibrator MV and the driver stage Tr, alternating voltage energy can be transmitted from the stationary part to the rotating part by way of the electromagnetic coupling between a stationary energy transmitter 16 and the energy receiver 17 rotating with the wheel. This is shown in detail in Figure 5 in which a current of fixed frequency flows through a stationary transmitter coil 21 connected to the chassis, the current being supplied by a direct voltage to alternating voltage transformer 22 which is fed from the battery 23 of the motor vehicle. The alternating electromagnetic field produced by the coil 21 induces a voltage in a coil 24 connected to the vehicle wheel, which voltage is rectified in a rectifier 25 rotating with the wheel and can be used to feed the multivibrator MV and the driver stage Tr.

Alternatively, in contrast to alternating voltage energy transmission of this kind, and in accordance with Figure 6, a generator-type energy coupling to the vehicle wheel can be used for feeding the resonant circuit by means of a permanent magnet.

The embodiment of Figure 6 incorporates a permanent magnet pole plate 27 which has north and south poles alternating in its longitudinal direction and can be secured to the vehicle such that a plurality of pole fields 28 and 29 alternating in this longitudinal direction move past, which pole fields are interconnected by a common, soft-magnetic iron yoke piece 30. This yoke piece is surrounded by an induction winding 31. When the pole fields of the soft iron system are located opposite the north and south poles, indicated by dotted letters, of the permanent magnet 27, the magnetic flux enters at the pole fields 28 and completes its path to the south poles of the pole plate 27 by way of the yoke piece 30 and the pole fields 29. During further rotation of the soft iron system, a voltage half cycle appears in the induction winding 31 until the north poles of the pole plate 27 have appeared opposite the pole fields 29. During further movement of the soft iron system, an oppositely polarized alternating voltage half cycle then appears in the induction winding 31. With a number of alternating voltage half cycles corresponding to the number of pairs of poles on the pole plate 27, an alternating voltage is produced which, by way of a rectifier 25 of the kind indicated in Figure 5, can serve to obtain a supply voltage for an oscillator circuit of Figure 1 which varies its frequency in dependence upon pressure, or for an RC multivibrator MV.

Claims

1. Apparatus for monitoring the air pressure in the tyre of a vehicle wheel, comprising a device which is arranged on the vehicle wheel for producing a magnetic field rotating with the vehicle wheel, and an induction loop which is

secured to the vehicle and which is subjected to the magnetic field of said device on the vehicle wheel when said device moves past it, said device including an electro-magnetic coil for producing said magnetic field rotating with the vehicle wheel and which carries an oscillatory signal of an electrical resonant circuit whose oscillating frequency is determined by an impedance which varies in dependence upon the air pressure prevailing in the tyre.

2. Apparatus as claimed in claim 1, wherein the frequency of the oscillating signal is determined by a capacitor whose capacitance varies in dependence upon the air pressure prevailing in the tyre.

3. Apparatus as claimed in claim 2, wherein the capacitor is disposed in or on the vehicle tyre.

4. Apparatus as claimed in claim 3, wherein the capacitor has at least one electrode whose distance from the second electrode of the capacitor is variable in dependence upon the air pressure prevailing in the tyre.

5. Apparatus as claimed in claim 4, comprising a diaphragm box which is subjected to the air pressure in the tyre and which includes two diaphragms which are secured at their edges in a pressure-tight manner and so as to be electrically insulated from one another, said diaphragms constituting said first and second capacitor electrodes respectively.

6. Apparatus as claimed in claim 5, wherein the diaphragm box has a central diaphragm which is disposed between the two outer diaphragms of the diaphrgm box which are subjected to the air pressure in the tyre, the central diaphragm constituting the counter-electrode for the two outer diaphragms which are electrically interconnected and are displaced in dependence upon pressure.

7. Apparatus as claimed in any of claims 2 to 6, wherein the capacitor and the electro-magnetic coil together form said resonant circuit, the latter circuit having a resonant frequency varies in the range of from approximately 50 kHz to 100 kHz in dependence upon pressure.

8. Apparatus as claimed in any of claims 1 to 6, wherein the pressure-dependent capacitor is part of an RC resonant circuit.

9. Apparatus as claimed in claim 8, in which said resonant circuit comprises an astable multivibrator.

10. Apparatus as claimed in claim 9, wherein a driver stage is disposed between the astable multivibrator and the electro-magnetic coil.

11. Apparatus as claimed in any of claims 6 to 10, wherein said device includes a wireless energy receiver which is disposed on or in the vehicle wheel for the purpose of feeding the resonant circuit with electrical energy and which cooperates with an energy transmitter installed at a fixed position on the vehicle.

12. Apparatus as claimed in claim 11, wherein the energy transmitter supplies electromagnetic oscillations of approximately 20 kHz to the energy receiver.

13. Apparatus as claimed in any of claims 6 to 10, wherein energy is transmitted electromagnetically from the vehicle to the vehicle wheel with the aid of a permanent magnet.

14. Apparatus as claimed in claim 13, wherein there is provided a soft iron system which rotates with the vehicle wheel, which has at least two mutually adjacent pole fields interconnected by a soft iron yoke piece and which has an induction widing embracing the yoke piece, said magnet being secured to the vehicle and having at least two poles which are located one behind the other in the direction of rotation of the vehicle wheel and which periodically lie opposite the pole fields of the soft iron system and magnetically permeate said pole fields.

15. Apparatus as claimed in claim 1, wherein the impedance is formed by an inductive position sensor, such as a short-circuit ring sensor connected to a diaphragm box.

16. Apparatus for monitoring the air pressure in the type of a vehicle wheel, substantially as hereinbefore described with reference to and as illustrated in Figures 1 and 2, or in Figure 3, or in Figure 4, or in Figure 5, or in Figure 6 of the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1981. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.